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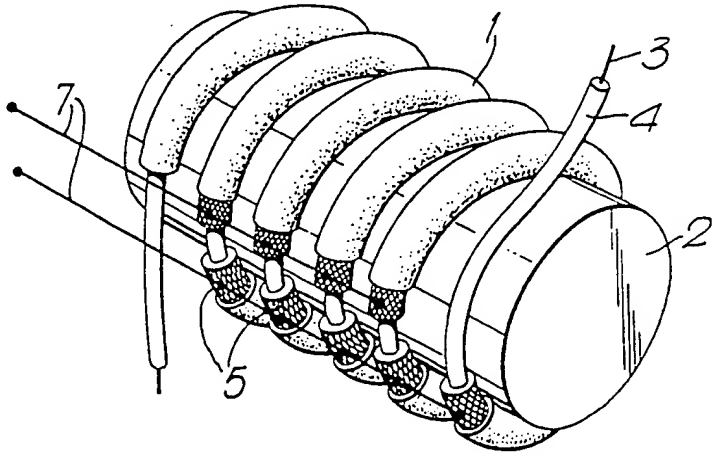
(54) **Pulse transformer**

(57) The amount of insulation needed in a high-voltage pulse transformer conflicts with the requirement to provide close coupling between the transformer windings in order to ensure sufficiently fast pulse rise times. A secondary winding is made up of a coiled length of wire 3 with an insulating sheath 4 and a primary winding is formed of a plurality of parallel connected winding sections 5. The windings can be made from a length of screened cable. Alternatively, the conductor sections 5 could be provided by electro-plating the sheath 4 after it has been wound into the required form. The winding could be formed on a core, for example a rod or pot core but preferably as a toroid on a ring-shaped core. The transformer may be used in a laser pump circuit in order to step up the output of a comparatively low voltage pulse generator to the high voltage required by the laser.

Fig. 1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig.1.

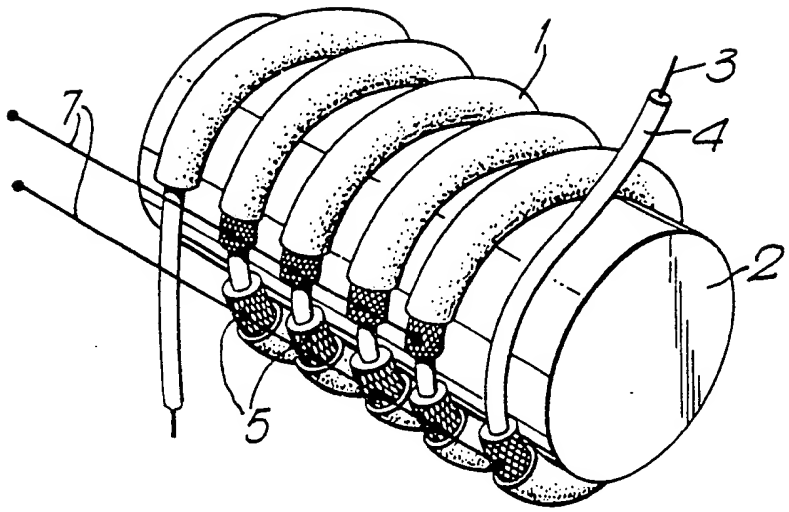
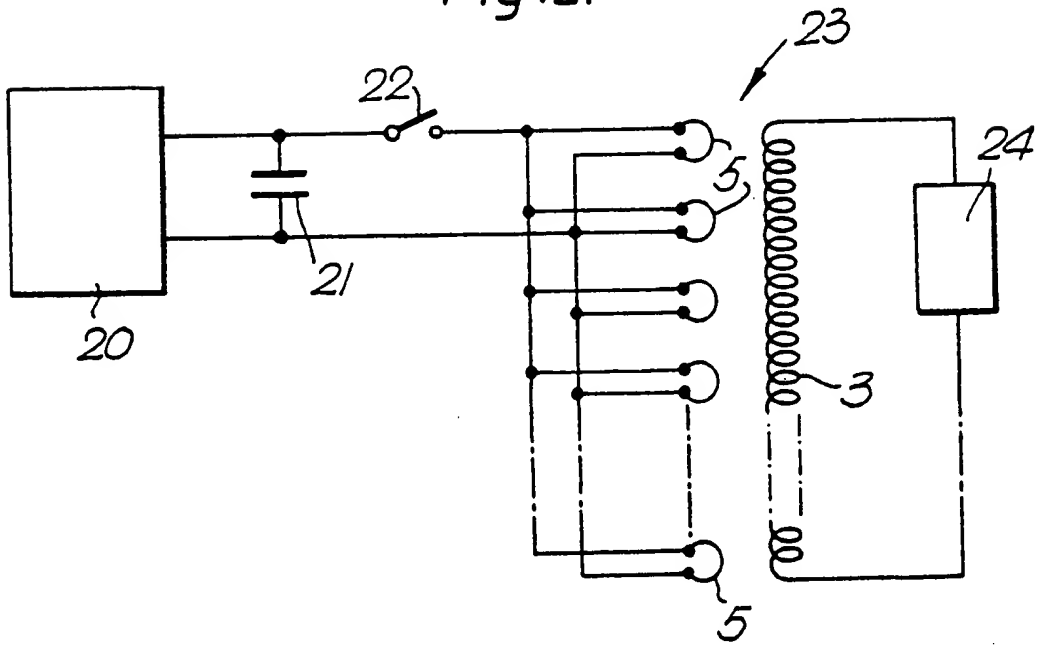


Fig.2.



SPECIFICATION
Transformers

This invention relates to transformers.

A high voltage pulse generator for pumping a gas discharge laser say, could usefully comprise a step-up transformer between the laser and a pulse generating circuit, a capacitor discharge circuit say or voltage doubling circuit. The pulse generating circuit could then operate at a comparatively low voltage and the relatively very high voltages needed to pump a gas discharge laser need only appear at the secondary side of the transformer. However, usually the high voltage pulses are required to have quite fast rise times which necessitates close coupling between the transformer primary and secondary windings. Close coupling on the other hand implies a reduced level of insulation between the windings and hence militates against high voltages.

The object of this invention is to provide a transformer which may be able more easily to achieve both satisfactory high voltage performance and sufficiently close coupling between windings.

A transformer of which a first winding comprises a wound length of inner conductor and of which a second winding comprises a plurality of outer conductor sections spaced along the inner conductor and each surrounding the inner conductor while being electrically insulated therefrom, the outer conductor sections being connected in parallel with one another. Said inner conductor may comprise a plurality of turns along each of which there extends a respective one of said outer conductor sections whereby said first and second windings respectively comprise a plurality of series turns and an equal number of parallel-connected single-turn winding sections.

Advantageously, an insulating sheath surrounds the inner conductor and separates it from the outer conductor sections. Also, the outer conductor sections may each be surrounded by insulating material.

The windings may be formed by a length co-axially screened cable of which the screen has been divided into a plurality of sections. As a further possibility, the windings may be made by coiling a length of conductor having an insulating sheath into the required form of the windings and then electro-plating the sheath to form said outer conductor sections.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing, in which:—

Figure 1 is a view of an air-cored transformer, and

Figure 2 is a simplified circuit diagram of a gas laser pump circuit incorporating the transformer of figure 1.

The illustrated transformer comprises a conductor member 1 wound on an insulating former 2 and consisting of a continuous inner conductor 3 surrounded by an insulating sheath 4 and a plurality of outer conductor sections 5 surrounding and spaced along the sheath 4 and themselves each being covered by an insulating material sheath 6. Each outer conductor section extends over one turn of the conductor member. Each end of each outer conductor section is exposed and is connected by a respective one of two lengths of wire 7 to the corresponding end of each other outer conductor section. *i.e.* so that the outer conductor sections are all connected in parallel. There is thus formed two windings, one comprising the inner conductor 3 and made up of a plurality of series turns while the other, formed of the outer conductor sections 5, comprises an equal number of parallel-connected single-turn winding sections. The winding has been made by taking a length of co-axial cable, baring the screen of the cable at spaced positions separated by the intended length of each turn of the conductor member 1, dividing the screen at each of these positions, and then winding the cable onto the former 2 as shown and connecting the wires 7 to the ends of the sections of screen, these screen sections of course forming the outer conductor sections 5 while the inner conductor of the cable forms the inner conductor 3.

The laser pump circuit of figure 2 comprises a charging circuit 20 operable to charge a capacitor 21 and a switch 22 for discharging the capacitor through the primary winding of a transformer 23 constructed as shown in figure 1. The transformer is arranged to step up the voltage of the discharge pulse from the capacitor *i.e.* the primary winding is the winding consisting of the parallel connected single turn sections formed by the screen conductor sections 5 in figure 1. The secondary winding, *i.e.* the inner conductor 3 of figure 1, is connected to the discharge path terminals of the laser 24. In contrast to the kind of laser pump circuit where a capacitor is charged to the high voltage required for the pump pulses then discharged by a switch directly into the laser, the figure 2 circuit has the advantage that the high voltages only appear while the firing pulse is being generated and then only on the secondary side of the transformer 23. Meanwhile, the primary winding side of the circuit, *i.e.* the charging circuit capacitor and switch only have to deal with comparatively much lower voltages and hence can comprise cheaper and less bulky components.

If desired, the primary and/or secondary winding of the transformer 23, which windings are isolated from one another throughout, could be grounded, preferably in a way which minimises any radio frequency interference that might otherwise be produced. The transformer 23 could be supplemented if desired by one or more further transformers (not shown) connected in tandem so as to achieve the required step-ratio.

Instead of each primary winding section comprising a single turn as shown, each section could comprise a plurality of turns. For example, in figure 1, the cable screen could be exposed and divided a/ positions spaced by two or more turns so that between each place where the screen is

exposed and connected to the wires 7 there will lie one or more turns of unexposed cable.

The transformer of figure 1 could be provided with a core simply by inserting a rod (not shown) of suitable core material such as ferrite into the former 2. However, to maximise the winding inductance for a given number of turns, a closed or gapless core, for example a ring shaped or pot core, is best. A possibly advantageous embodiment would comprise a ring shaped core with the winding extending all round the core so as to form a toroidal transformer.

As will be appreciated, for maximum coupling, the insulating material used in the cable, particularly the insulating sheath 4, needs to be as thin as possible while having sufficient electrical strength to avoid breakdown at the intended voltage of operation. Quite possibly therefore, standard commercially available co-axial cable which is designed for different criteria, *i.e.* for which a uniform inner conductor to screen spacing and a precisely defined chracteristic impedance are most important, may not give the best results. In fact, the cheaper forms of screened cable without any carefully designed impedance may be better. Of course, if no suitable cable is available for a particular set of transformer parameters, one may be specially made for the purpose. It might be better. Of course, if no suitable cable is available method. For example, a length of wire with a suitable insulating sheath could have the outer conductor sections formed thereon by any suitable method, by electro-plating say. Such electro-plating could be done in-situ, *i.e.* after the length of insulated wire has been wound to the required form of the winding.

CLAIMS

1. A transformer of which a first winding comprises a wound length of inner conductor and of which a second winding comprises a plurality of outer conductor sections spaced along the inner conductor and each surrounding the inner conductor while being electrically insulated therefrom, the outer conductor sections being connected in parallel with one another.

2. A transformer according to claim 1, wherein said inner conductor comprises a plurality of turns along each of which there extends a respective one of said outer conductor sections whereby said first and second windings respectively comprise a plurality of series turns and an equal number of parallel-connected single-turn winding sections.

3. A transformer according to claim 1 or 2, wherein an insulating sheath surrounds the inner conductor and separates it from the outer conductor sections.

4. A transformer according to claim 3, wherein said outer conductor sections are each surrounded by insulating material.

5. A transformer according to claim 3 or 4, wherein said windings are formed by a length of co-axially screened cable of which the screen has been divided into a plurality of sections.

6. A transformer according to claim 3 or 4, wherein the windings are made by coiling a length of conductor having an insulating sheath into the required form of the winding and then electro-plating the sheath to form said outer conductor sections.

7. A transformer substantially as hereinbefore described with reference to figure 1 of the accompanying drawings.

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